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(54) **RF coupler for a shielded transponder**

(57) A magnetic transponder (30) is mounted around the valve fitting (16) on the ferrous body (12) of a compressed gas bottle (10) to enable remote identification of the bottle. A metal valve guard (40) encircles the valve fitting (16), for the protection of the fitting during transportation, which shields the bottle transponder from an external reader/exciter. In order to couple RF signals between the reader/exciter, which is outside of the valve guard and the transponder, which is inside of the valve guard, a coupler is provided having a first receive and transmit antenna outside of the valve guard and a second transmit receive and transmit antenna inside of a valve guard adjacent the transponder antenna. Electrical current carrying wires interconnect the two coupler antennae and extend through a wire receiving aperture formed in the valve guard. Alternative forms of coupler are shown in figures 4, 5.

FIG. 1.

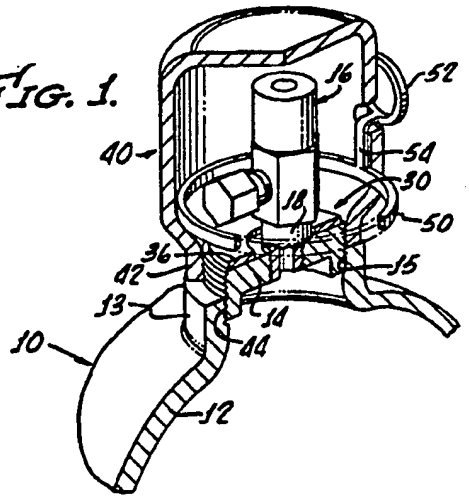

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FIG. 1.

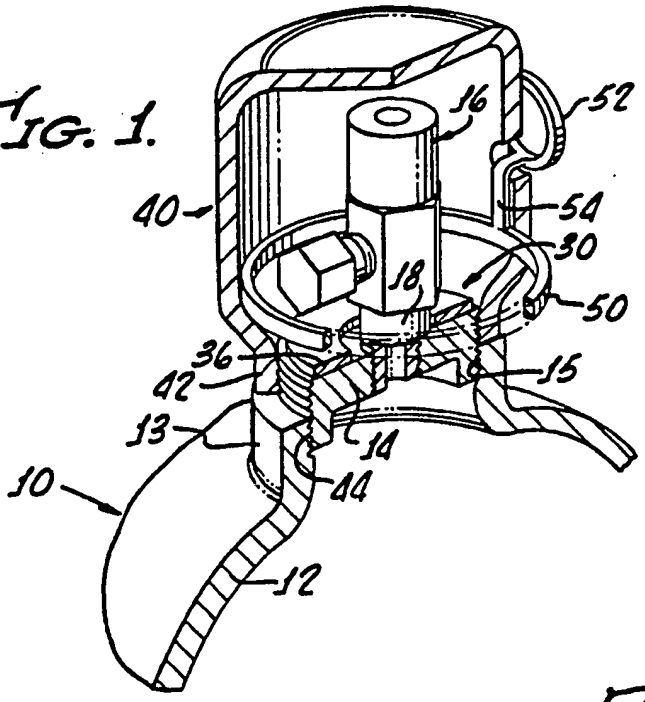
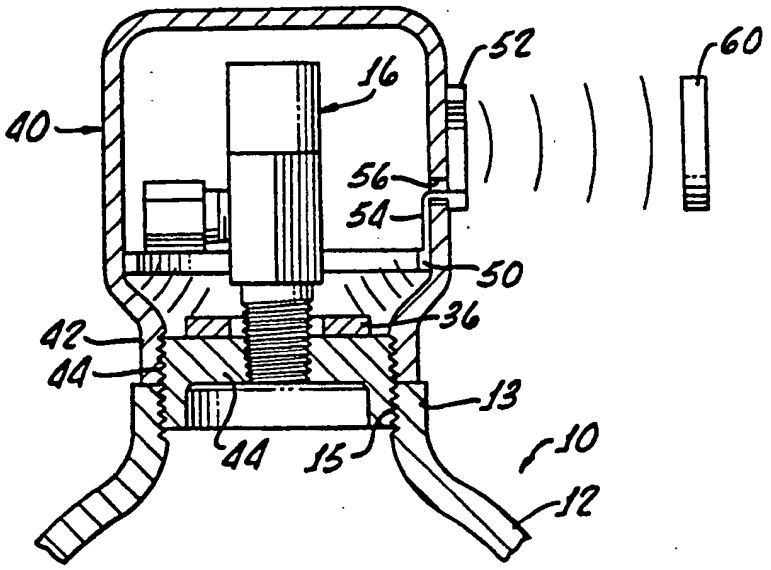


FIG. 2.



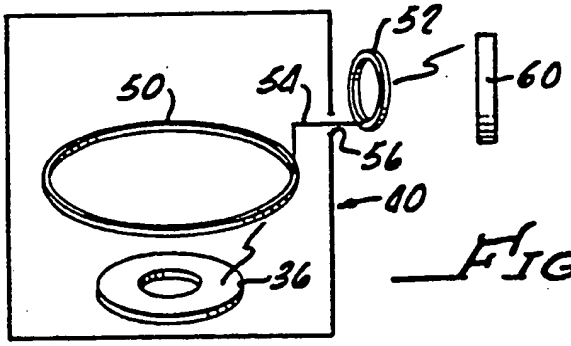


FIG. 3.

FIG. 4.

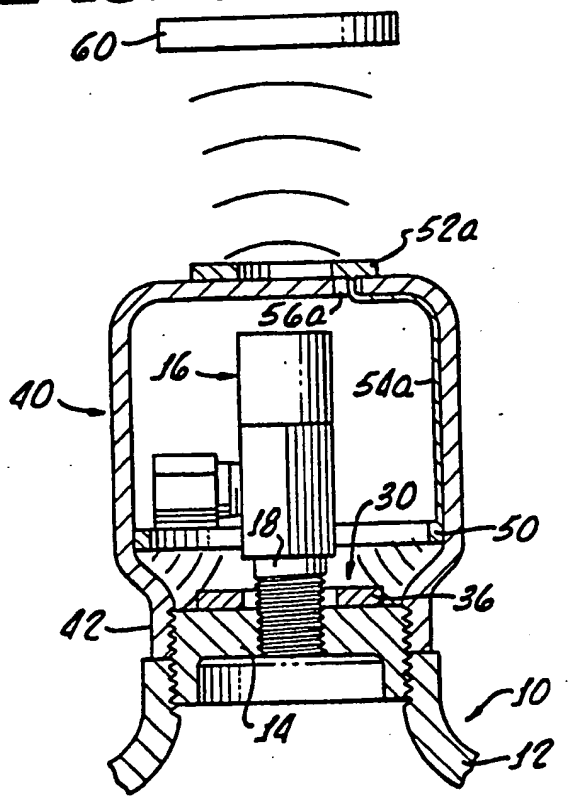


FIG. 6.

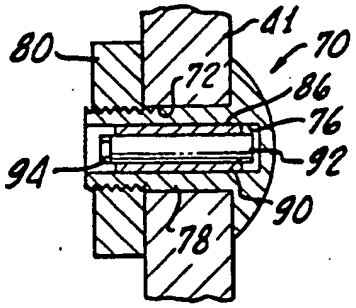


FIG. 7.

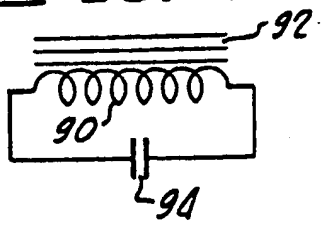
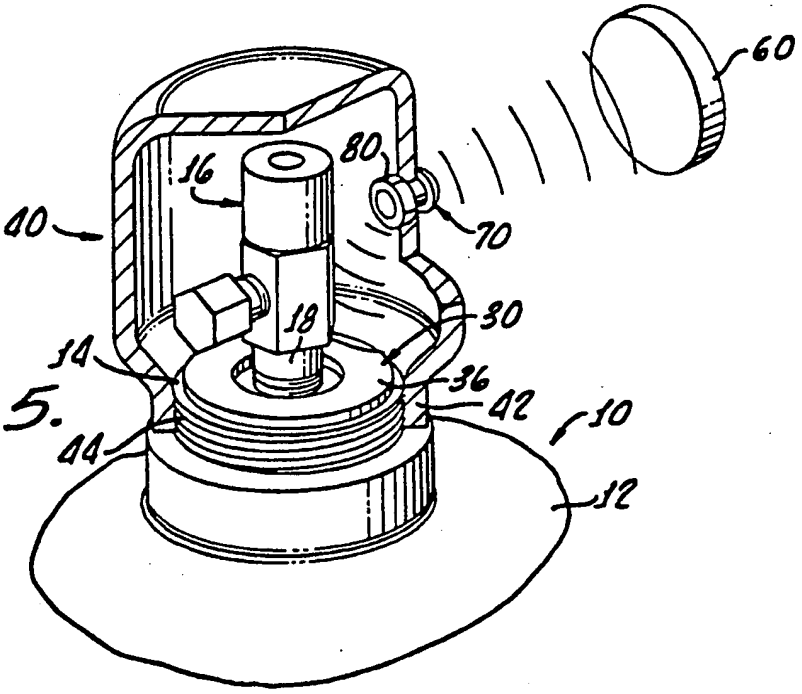


FIG. 5.



THROUGH METAL R.F. COUPLER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the remote identification of objects and more particularly concerns remote identification of objects that are shielded from transmission of radio frequency signals.

2. Description of Related Art

Remote magnetically coupled identification systems of the type shown in the United States Patent to Milheiser 4,730,788 embody a reader/exciter that transmits a radio frequency exciter signal. The signal produces a magnetic flux field that is magnetically coupled to a transponder antenna mounted upon a device to be identified. The magnetic flux field coupled to the antenna energizes transponder circuitry which assembles an identification code that is fed back to the transponder antenna which then transmits a return information signal to be received by the reader/exciter. Systems of this type have heretofore been limited to application where there is a magnetically unobstructed path between the reader/exciter and the transponder antenna. Thus, it has not been possible to mount a transponder behind a metal shield, that is, behind

any device having a low magnetic reluctance, since such a device would block transmission of magnetic signals.

Among the many applications of such a magnetic transponder for remote identification is the identification of compressed gas bottles such as cylindrical ferrous metal containers commonly used for holding compressed nitrogen, oxygen or the like. Such containers are frequently reused over a lifetime of many years. The bottles are filled at a suitable central location and distributed for use by customers who rent the bottles and their contents. The bottles are then returned for refilling and reuse. It is important to be able to identify specific bottles to facilitate billing of customers and to maintain records of history, locations and other information of individual bottles.

To keep track of such bottles, it is common practice to use metal dies to stamp identification numbers on the exterior surface of the bottle so that the identification numbers can be visually read and locations and uses can thus be recorded. It is not uncommon for such bottles to be stored for periods of years in hostile environments so that the ferrous bodies become rusted and identification numbers illegible, readable only with difficulty. It may be necessary to brush rust from the bottle or otherwise clean its surface to enable reading of such stamped numbers. This, of course, is difficult and time consuming.

It has been suggested to mount the remote magnetic transponder to a hole drilled in the bottle wall. However, it is found that the metal of the bottle wall absorbs much of the magnetic flux of a magnetic transponder so that significant reduction in range is encountered. In fact, it is difficult to read such transponders, mounted within a hole in the bottle wall, at distances greater than two to three inches. Furthermore, difficulties are encountered in positioning the exciter/reader close enough to excite the transponder and read its return signal while at the same

time avoiding physical contact with the bottle fitting. Problems of this type in mounting of a magnetic transponder on a metal wall container have been solved by use of a transponder design and configuration described in my co-pending application Serial No. 08/094,672, filed July 14, 1993, attorneys' Docket No. PDH91003, 89-42-D. The disclosure of this co-pending application is incorporated herein by this reference as though fully set forth. As described in this patent application, a transponder for a compressed gas bottle employs an antenna configured and arranged to minimize decreased range effects of the container body on antenna range. The antenna employs a flat air core coil mounted on a bottle upper shoulder and surrounding the bottle fitting. The arrangement works quite well where the fitting remains uncovered. However, in many situations, and particularly for handling and transport, a ferrous metal valve guard is attached to the upper end of the bottle to completely enclose the metal fitting. The valve guard, therefore, completely encloses the transponder that is mounted on the bottle shoulder and surrounds the fitting. This blocks magnetic signals despite the optimum antenna configuration that patterns magnetic flux lines so as to extend the range of magnetic coupling. The presence of such a ferrous metal valve guide completely shields the transponder antenna that is positioned entirely inside the metal valve guard and thus the transponder cannot operate when the valve guard is in place. The transponder can be read only when the valve guard is removed. But, it is difficult and time consuming to unscrew and detach the valve guard, particularly when many bottles with valve guards are to be identified.

This is but one example of many situations in which a transponder that is to be magnetically coupled to a remote exciter/reader has its field of transmission and reception completely blocked by some type of ferrous object. Other examples include metal containers of many different types

that could usefully contain an identifying transponder, but cannot because the metal of the container blocks remote communication.

Accordingly, it is an object of the present invention to provide remote coupling by methods and apparatus that avoid or minimize above mentioned problems.

SUMMARY OF THE INVENTION

In carrying out principles of the present invention in accordance with a preferred embodiment thereof, a magnetically coupled remote identification system comprises a shielding member having a low magnetic reluctance, an exciter/reader including means for transmitting a radio frequency magnetic excitation signal and means for detecting a responsive return signal, wherein the return signal includes an information signal, and wherein the exciter/reader is positioned on one side of the shielding member. A transponder is provided on the other side of the shielding member and shielded from the exciter/reader by the shielding member. The transponder includes a circuit for generating an information signal and a transponder antenna connected with the circuit for receiving and transmitting radio frequency magnetic excitation signals. A coupler is provided, extending through the shielding member and having first and second coupling parts on opposite sides of the shielding member, each capable of transmitting and receiving radio frequency magnetic signals. Means are provided, extending through the shielding member, for transmitting electrical signals between the coupling parts, with the second coupling part being positioned adjacent to the transponder antenna.

According to a communication method of the invention, a compressed gas bottle having an upper shoulder has a valve guard on the shoulder surrounding the fitting. The gas bottle is identified by mounting on the shoulder a magnetically responsive transponder having transponder

circuitry for transmitting a bottle information signal and having an annular transponder antenna, wherein the step of mounting comprises positioning the antenna on the bottle within the valve guard, forming a hole in the valve guard, mounting a radio frequency coupler in the hole with a first coupling part outside of the valve guard and a second coupling part inside of the valve guard, transmitting a radio frequency signal outside of the valve guard between a remote exciter/reader and said first coupling part, transmitting a radio frequency signal within said valve guard between said transponder antenna and said second coupling part, and electrically coupling said first and second coupling parts to each other.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawings:

FIG. 1 is a pictorial illustration, with parts broken away, showing a gas cylinder with a valve assembly and valve guard and having an identifying transponder affixed thereto, including a coupler embodying principles of the invention.

FIG. 2 is an elevational section of the gas cylinder and transponder of FIG. 1.

FIG. 3 is a schematic illustration of parts of the transponder and coupler of FIGS. 1 and 2.

FIG. 4 is a view similar to FIG. 2 showing a modified coupler arrangement.

FIG. 5 is a pictorial illustration with parts broken away similar to FIG. 1 showing another modified form of coupler.

FIG. 6 is an enlarged fragmentary sectional detail showing the coupler of FIG. 5.

FIG. 7 illustrates the electrical circuit of the coupler of FIGS. 5 and 6.

DESCRIPTION OF PREFERRED EMBODIMENTS

As illustrated in FIG. 1 a conventional ferrous metal compressed gas cylinder 10 includes a right circular cylindrical heavy walled iron body 12 having a neck 13 within which is threadedly fixed a cap plug 14 having an internally threaded aperture 15. Threadedly secured to and within the aperture 15 is a connection valve fitting 16 that is detachably but fixedly secured to the bottle and its cap. Usually the fitting is made of brass or some other non-ferrous (nonmagnetic) metal. Fitting 16 includes a lower threaded connecting neck portion 18 that is threadedly engaged in and sealed to the threaded aperture 15 in the cap 14. In a normal upright position of the bottle, its axis is vertical and an upper shoulder on the upper side of cap 14 is horizontal. The bottle configuration illustrated in FIG. 1 is merely exemplary, and it will be readily understood that various other bottle and fitting configurations are known and may be employed with the present invention. Furthermore, a metal bottle is only one of many different applications of the present invention. The bottle is described primarily to explain one application of the invention where a shielding member blocks remote magnetic communication.

For identification of the specific bottle 10, a transponder 30 having a generally flat annular form is positioned on top of the upper surface or shoulder of cap 14 and surrounds the neck 18 of the valve fitting 16. The transponder includes a flat pancake annular antenna housing 36 having a circuit chip (not seen in FIG. 1) fixedly connected to an antenna (not shown) within housing 36. The circuit chip is fixedly mounted within the antenna housing and electrically connected to the antenna, which is merely a coil of wire within the housing 36.

A valve guard 40 in the form of an inverted open ended circular cylindrical tube has a decreased diameter lower end 42 internally threaded and threadedly engaged with

threads 44 on the exterior of the cap 14. Thus the valve guard, generally made of a ferrous metal such as iron or steel, completely surrounds the fitting 16 and transponder 30 and is detachably connected to the upper portion of the bottle so as to provide physical protection for the valve assembly 16, to prevent damage to the valve assembly during shipping and handling.

A coil of wire comprising an internal coupling antenna 50 is fixedly mounted to an interior surface of the valve guard 40 at a lower portion thereof adjacent the transponder housing 36. Internal antenna coil 50 circumscribes a lower portion of fitting 16 and is electrically connected to an external coupling antenna coil 52 by means of a pair of electrical conductors 54 that extend through a hole 56 in the wall of valve guard 40. External antenna 52 is suitably secured, as by bonding or the like, to the exterior surface of valve guard 40.

The transponder described herein is employed in remote magnetically coupled identification systems of the type shown in the United States Patent to Milheiser, 4,730,788. The transponder antenna in housing 36, together with its circuit chip (not shown), embody circuitry of the nature described in detail in the Milheiser patent. Transponders of this general type are made by Hughes Identification Devices, Inc. and sold as Prox Card Reader or other types of transponder systems which include various types of readers, scanners and transponders for a variety of identification purposes. Such devices have reading ranges in the order of 8 to 12 inches.

As shown in the patent to Milheiser and described in detail therein, and also as embodied in the Hughes Identification Devices transponders, this type of magnetically coupled identification system includes a reader/exciter such as that shown at 60 in FIG. 2. The reader/exciter, which is not connected with the bottle or any of its parts or to the transponder, transmits a radio

frequency exciter signal at a frequency which may be, for example, in the order of about 125 or 400 kilohertz. Assuming absence of the valve guard 40, the transmitted signal produces a magnetic flux field that is magnetically coupled to the transponder antenna to energize the latter and provide power for the transponder identification and data read out circuitry. The transponder carries no battery or other source of stored power. An identification code signal and other data are stored in the transponder circuits.

This description assumes unobstructed transmission of radio frequency and magnetic signals between the transponder antenna and the reader/exciter. Upon energization of its antenna (within housing 36), the transponder assembles an information signal, which may contain identification code and other data related to the individual bottle. This information signal is fed to the transponder antenna to cause the latter to transmit a return or information signal that is received (with valve guard 40 removed) by the reader/exciter, where it is detected and employed for selected use. The described apparatus operates in the manner set forth herein when the valve guard has been removed from the bottle. However, it may not always be feasible to remove the valve guard from the bottle to enable operation of the transponder or such removal and re-attachment may be unnecessarily and undesirably time consuming. Furthermore, the gas bottle may be in such a position that access to the valve guard 40 for the removal and replacement is not readily available.

Accordingly, a coupler is provided to receive signals from the reader/exciter 60, transmit such signals through the shielding wall of the valve guard (when the latter is attached to the bottle) and to then re-transmit such signals to the transponder antenna 36. The coupler also works in reverse to receive signals transmitted within the valve guard 40 from the transponder antenna and to

re-transmit such signals externally of the valve guard to the reader/exciter 60.

As previously described, the coupler includes an external antenna 52 that is mounted on the outside of the valve guard 40 and an internal antenna 50 that is mounted within the interior of the valve guard assembly closely adjacent the transponder antenna 36. A pair of electrical leads 54 electrically interconnect the inside and outside antenna 50, 52 and extend through the hole 56 in the wall of the valve guard. Thus the coupler is effectively a part of the valve guard when the valve guard is removed, the coupler is also removed (but is not needed). When the valve guard is in place, the coupler, now needed, is automatically properly positioned. Accordingly, with the valve guard and coupler in place, an RF signal transmitted by the reader/exciter 60 is received by outside antenna 52 and electrically transmitted by leads 54 to the inside antenna 50. The latter transmits its signals through the short space within the interior of the valve guard to the RF transponder antenna 36 which receives the transmitted radio signal and operates as previously described.

As described above, the transponder responds to a received signal and assembles a data and identification signal which is retransmitted by the transponder antenna. This signal is transmitted across the short space within the interior of the valve guard to the inside antenna 50 and electrically transmitted via conductors 54 through the hole in the metal shielding member 40 to the outside antenna 54 mounted on the shielding member. The outside antenna transmits its signal to the exciter/reader 60 which receives the signal for utilization as described above.

A modified arrangement is illustrated in FIG. 4 which shows all parts identified by the same numerals. However, in this embodiment, the external antenna 52 of FIGS. 1 and 2 is now repositioned on the top of the valve guard as shown at 52a in FIG. 4. A hole 56a formed in the upper

side of valve guard 40 receives wires 54a which extend between and electrically interconnect the outside coupling antenna 52a with the inside coupling antenna 50. The latter is positioned, as described in connection FIG. 1 and 2, inside the valve guard adjacent the transponder antenna 30. The configuration of FIG. 4 operates in the same way as the configuration of FIGS. 1-3.

FIGS. 5, 6 and 7 illustrate still another modification of the coupling arrangement for the transponders described herein. The bottle and the valve guard remain the same, including the compressed gas container 14 having a detachable sealing closure cap 14 into which is threaded a valve fitting 16 having a neck that is surrounded by the transponder 30, all configured and arranged exactly as previously described in connection with FIGS. 1, 2, 3 and 4. In this embodiment, however, instead of having separate inside and outside antenna coils interconnected by wires extended through a hole in the valve guard, an elongated cylindrical coupler assembly 70 is fixedly mounted to the valve guard 40 and extends through a hole therein as can best be seen in FIG. 6. Valve guard 40 includes a valve guard wall 41 having a hole 72 extending thereto. Coupler 70 includes a plastic or other non-ferrous housing in the form of a headed bolt having an enlarged head 76 interconnected with or integral with a cylindrical shank 78 that extends through the hole 72. The free inner end of shank 78 projects inwardly beyond the wall 41 of valve guard 40 and is externally threaded for reception of a nut 80 that fixedly secures the coupler housing to the valve guard wall within the hole 72.

Shank 78 of the coupler housing is formed with a blind opening 86 in which is fixedly secured a cylindrical coil 90 wound about a ferrite core 92. A capacitor 94 is connected in series circuit with the coil. The electrical circuit of the series connected coil and capacitor is illustrated in FIG. 7.

Coupler 70 includes the ferrite wound coil, which has an axial length such that one end of the ferrite core and coil is positioned outside of the wall 41 and the other end of the ferrite core and coil is positioned inside of the valve guard wall 41. Thus, the outside end of the coil and core acts as a receiving transmitting antenna for signals fed to and from transponder 60 and the inside end of the coil and core acts as a receiving transmitting antenna for coupling with signals transmitted to or from the coil of the transponder 30.

The various arrangements illustrated and described herein allow use of a remote transponder to communicate with a transponder positioned within and fully shielded by a ferrous metal shielding device such as the iron valve guard 40 and allow the transponder to operate just as if the shielding member were not in place.

The invention has been described with particular detail as specifically designed for use with a compressed gas metal bottle having a valve guard that completely encloses the transponder antenna. The arrangement of the invention eliminates the required task of unscrewing the valve guard of the compressed gas cylinder to read its transponder and enables direct communication with the transponder by means of normal reader/exciter equipment positioned on the outside of the valve guard. Principles of the present invention are not limited to use for identification and compressed gas bottles, but are equally applicable to other devices such as, for example, any type of sealed metallic container such as containers of food, munitions or other items. Such metallic containers act as an effective Faraday screen to block communication. However, it is only necessary to place a transponder within the sealed metal container and to provide a coupler of any one of the configurations shown and described above mounted in the container wall to enable communication between the

reader/exciter equipment on the outside of the container and the transponder mounted inside the container.

What is Claimed is:

1. A magnetically coupled remote identification system comprising:

a shielding member having a low magnetic reluctance,

an exciter/reader including means for transmitting a radio frequency magnetic excitation signal and means for detecting a responsive return signal, wherein the return signal includes an information signal, said exciter/reader being positioned on one side of said shielding member,

transponder means on the other side of said shielding member and shielded from said exciter/reader by said shielding member, said transponder including,

circuit means for generating an information signal, and

a transponder antenna connected with said circuit means for receiving and transmitting radio frequency magnetic excitation signals, and

a coupler extending through said shielding member, said coupler comprising

a first coupling part on said other side of said shielding member and positioned near said transponder antenna,

a second coupling part on said one side of said shielding member,

each said coupling part including means for transmitting and receiving radio frequency magnetic signals, and

means extending through said shielding member for transmitting electrical signals between said first and second coupling parts.

2. The system of Claim 1 including a metal container that is to be identified, said shielding member comprising a guard on the container for protecting a section of the container, said transponder being mounted to said container at the section protected by said guard, whereby said radio frequency magnetic excitation signal is transmitted through said guard by said coupler between said exciter/reader and said transponder.

3. The system of Claim 1 wherein said first and second coupling parts comprise first and second coupling antennae, and wherein said means extending through said shielding member comprise electrical conductors connected to and between said coupling antennae.

4. The system of Claim 1 wherein said coupler comprises an elongated magnetic core extending through said shielding member, an elongated coil wound on said core, and a capacitor connected with said coil, said core and coil having first and second ends respectively forming said first and second coupling parts.

5. The system of Claim 1 wherein said shielding member has a hole extending there through, a non-magnetic mounting body fixed in said hole, and an elongated recess in said mounting body, said magnetic core and coil being secured to said mounting body within said elongated recess.

6. The system of Claim 1 wherein said shielding member has hole extending there through, a plastic bolt having a threaded shank extending through said hole and secured to said shielding member, said bolt having an elongated recess in said shank, said magnetic core and coil being secured to said bolt within said elongated recess.

7. The system of Claim 2 wherein said metal container is a compressed gas bottle having an upper shoulder and a connecting fitting extending from said shoulder, said guard comprising a fitting guard surrounding said connecting fitting and having a hole extending there through, said coupler extending through said hole from exterior to interior of said fitting guard.

8. A method of identifying a compressed gas bottle having an upper shoulder, a non-ferrous valve fitting extending from said shoulder, and a metal valve guard on said shoulder surrounding said valve fitting, said method comprising the steps of:

mounting on said shoulder within said valve guard a magnetically responsive transponder having transponder circuitry for transmitting a bottle information signal and having an annular transponder antenna,

forming a hole in said valve guard,

mounting a radio frequency coupler in said hole with a first coupling part outside of said valve guard and a second coupling part inside said valve guard,

transmitting a radio frequency signal outside said valve guard between a remote exciter/reader and said first coupling part,

transmitting a radio frequency signal within said valve guard between said transponder antenna and said second coupling part, and

electrically coupling said first and second coupling parts to each other.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report) 16	Application number GB 9405973.0
Relevant Technical Fields (i) UK Cl (Ed.M) H4L (LADA, LADX) (ii) Int Cl (Ed.5) G01S 13/74; G06K 7/08; H01Q 1/12, 1/22; H04B 5/00	Search Examiner JOHN CAGE Date of completion of Search 13 JUNE 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: WPI	Documents considered relevant following a search in respect of Claims :- 1-8

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A	EP 0586083 A2 (HUGHES)	

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